The International Society for Ecological Psychology

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Well I told you it would be hard to do Newsletters and the journal at the same time. Indeed, it really has been a year since you were sent the last Newsletter. However, you should have received three issues of the journal in that time. If not, let me (Bill Mace) know immediately.

ELECTION

Seven people were elected to the Board at the meeting in Storrs last October (1988). Current Board members are:

'87–'89	'88–'90
Claudia Carello	Alan Costall
Carol Fowler	Eleanor Gibson
Walter Gerbino	James J. Jenkins
Claes von Hofsten	Ulric Neisser
William M. Mace	Edward S. Reed
Robert E. Shaw	Sverker Runeson
James Todd	Esther Thelen
William H. Warren, Jr.	

MEETINGS

ICEPA5
The Fifth International
Conference on Event Perception and Action
"Coupling Perception and Action"
Miami University
July 24 - 28, 1989

Len Mark, Cathy Dent, and their colleagues at Miami, plus the participants who attended, together fashioned a memorable conference that left people eager for Number 6. Several people who remember the first conference in 1981 remarked on the contrast. In 1981 questions of how to do ecological research and whether or not much research would be done were common. In 1989, not only was there a delicious array of results reported, but the results frequently represented patterns of findings from sustained research programs. Moreover, some of the programs represented collaborations formed at previous ICEPA's. Many others developed during the week at Miami.

CONFERENCE FIRSTS. **(1)** This was our first conference to include the awarding of an honorary degree (Miami University to Jackie Gibson). **(2)** Daily newsletters. Len Mark arrived at his office soon after sunrise each day of the conference to prepare a daily schedule that included necessary announcements for the day as well as a complete (up to date) program. A complete supply was waiting as people filed in for the first talks each morning. These make a useful record of the conference in their own right. If you were not there, try to get copies from someone who was. If you still have yours, hang on to them. **(3)** Spontaneous internal organizing. Dean Owen organized an evening discussion on "Kinematics specifies dynamics" Wednesday night, featuring Sverker Runeson, Dennis Proffitt, and dozens of other thirsty truth seekers. Don Owings and Richard Coss called a meeting of those interested in topics raised at the animal symposium. People with primary commitments to a variety of areas chose to attend. Other groups that convened in answer to semi - formal "calls" included Arts and Esthetics, Human Factors (Ergonomics), and Social & Clinical. Even less formal, but no less notable, were groups on Culture and Ecological Psychology, and Injury prevention in children. The spontaneous creation of these groups allowed people to discover other like - minded colleagues more than talks, posters, and party talk alone would have. One might worry that such groups would isolate themselves from each other and lead Ecological Psychology down the path to an APA style fragmentation. However, an astonishing (to me) number of people attended the sessions on a full range of topics presented during the time they were in town. Few people were ducking in and out, coming only to talks in their own specialties. For example, clinical and social psychologists attended the full range of experimental sessions. Experimentalists attended the clinical and social symposium. People from a full range of specialties were at the Human Factors talks as well as the Animal Symposium. Our programs are designed with the intent that good work in one area can inform that of another, and that truly ecological psychology requires a disciplined cooperation across subspecialty areas. Nevertheless, seeing the widespread interest in the conference as a whole was as surprising as it was gratifying. So much for cynicism. The fact that talks all were given in plenary sessions and that there were

no parallel sessions surely played an important role in holding the week together. (4) T-shirts. Another first. (5) A contest to guess how many BITNET messages passed in and out of Len and Cathy's accounts to organize the conference. (Winner: Cathi Best. She guessed 2350 and the correct answer was 2354!)

I compiled very rough lists of people who attended some of the specialty group meetings. They are listed here as a way to help others who were not in Miami to know who to contact to join in any informal communication that is continuing. Bear in mind that these lists are neither exhaustive nor mutually exclusive. Your reporter had spotty sources. Some of the meetings did occur in parallel and the decision to meet, in some cases was made on the spur of the moment and notification passed by word of mouth. These are not membership rosters, just collections of people who met together at Miami. **Animal Behavior and Context.** Owings, Coss, Lickliter, Johnston, Pickering, Rowe, Burke, Burton, Giszeter, Michaels, Treffner, Turvey. **Ergonomics.** Barac, Dainoff, Dainoff, Flach, Flascher, Francis, Guiard, Guski, Heine, Lintern, Mark, Mestre, Norman, Overbeeke, Owens, Riccio, de Smets, Stappers, Stoffregen. **Arts and Esthetics.** Cabe, Grey, Hagen, Hayes, Knobler, Lynch, Mace, Overbeeke, Pufall, Shaw, de Smets, Stappers, Sternad. **Social and Psychotherapy.** Cavanaugh, Good, Krugman, Lemery, Lombardo, Matthews, Pallay, Stote, Trierweiler. **Ecological Psychology & Culture, Accident Prevention.** Harry Heft and Ed Reed are good contacts for people interested in either of these groups.

The conference ended with an inspired Friday evening banquet, capped by memorable performances from Piet van Wieringen (inviting people to Amsterdam) and Michael Turvey (summarizing the conference). Contrary to what I believed at the time, there *is* an audio tape of these remarks. As usual, anyone interested in audio tapes of talks should contact Stavros Valenti, Dept. of Psychology, Hofstra University, Hempstead, NY 11550, also known as Psyssv@Hofstra.Bitnet.

Walter Gerbino showed that ICEPA's could have nice looking, useful programs. Len and Cathy followed Walter's example and produced a beautiful one — 206 pages, 8 $\frac{1}{2}$ x 11 format, containing the full week's program (including a list of all posters), abstracts, and list of participants (with addresses). While extra copies are available, you can still get them from Len for $ 10. Send your money and request to: Len Mark, Department of Psychology, Miami University, Oxford, Ohio 45056 USA.

CONFERENCE PICTURE. Tom Stoffregen again submitted the low bid for taking the conference picture and got the contract. To purchase a print write to Tom at the Department of Psychology, University of Alabama, Tuscaloosa, AL 35487 or TStoffre@UA1VM.Bitnet.

1989 Annual Meeting
Dartmouth College
Oct 20-21

You should have received at least the first announcement of this meeting from Carol Fowler. If you think you've been passed by and want to know what's happening, contact me or Carol very soon. (Electronic mail: Carol.A.Fowler@Dartmouth.Edu, WMace@Trincc.Bitnet).

Let me remind you or inform you for the first time that by statute we hold the ISEP Annual Meeting every October, and that by vote of the membership, we have designated the third Saturday in October to be the day of our Business meeting. Mark your calendars now.

1990 Spring Meeting (US)
University of Illinois
Champaign-Urbana, Il

Members and friends at the University of Illinois already are busy planning a late spring ISEP meeting. You'll hear more as the details develop.

1990 Spring Meeting (Europe)
CNRS
Marseille, France

Daniel Mestre, in Marseille, decided at Miami that it was time for an ISEP meeting aimed more at Europeans. Tentatively, plans are to try to meet this spring (1990). Our Fall Annual Meeting is officially a meeting of the whole Society, but in practice only a few people from outside the U.S. are able to attend. German speaking members now have organized formally, and the British meet regularly. This would be the first attempt to convene primarily Europeans. Anyone interested in helping, or just getting more information, should contact Daniel Mestre. By electronic mail he is reached at Patre@Frmop11.Bitnet. Through the Post Office, he is at: Cognition et Mouvement, UA CNRS 1166, IBHOP, Traverse Charles Susini, 13388 Marseille, CEDEX 13, FRANCE. Phone: 33 91 66 00 69 FAX: 33 91 61 14 20.

The Sixth International Conference on Event Perception and Action

Free University of Amsterdam
August 25 - 30, 1991

The Dutch organizers of the next Event Conference arrived at Miami with a well worked out plan — so much so, in fact, that rumors spread that the program was fixed down to the last speaker. This was and is not true. There was a polished looking flyer circulated in Ohio. However, the flyer said its contents were tentative and meant it. The preparation that already has gone into the next Conference is stunning, however. While content and format decisions remain modifiable, anyone worried that something significant might be left out should consult one of the organizers *very soon*. The suggested symposium topics circulated at Miami were: Locomotion, Picture perception and Motion Perception, Reaching and Grasping, Ball Skills, Ecological Realism, Evolution and Development, Flow perception: Information and Mechanisms, and Serial Order in Behaviour.

Constructive discussion and commentary should be directed to Peter Beek, Reinoud Bootsma, or Piet van Wieringen. Their department address is: Faculty of Human Movement, Department of Psychology, Free University, P.O Box 7161, 1007 MC Amsterdam, The Netherlands. The conference electronic mail address is ICEPA6@SARA.NL.

Gibson Memorial Lecture

Michael Turvey will give the 1989 James J. Gibson Memorial lecture at Cornell University, in Ithaca, New York next month. It will be on Friday, October 13. Most people who receive this newsletter will receive an official announcement of the lecture, but if you do not, you can contact the Department of Psychology at Cornell for details. Traditionally, the lectures are in the afternoon.

Handbook of Ecological Psychology: A Call for Ideas

About 5 or 6 years ago the idea of publishing a handbook of ecological psychology came up. Nothing happened, largely because the idea seemed a bit premature. discussion at the Miami Conference in August, however, concluded that the time has come; we have more people doing more research and theory on more topics. At the present, and very preliminary, stage I'm taking the lead in developing ideas for the contents of the handbook.

I hereby solicit (actually plead for) your help with this project. Send ideas. I see, at least, two topics with which your input would help: general goals of the book and specific topics. First, just what is it that we want the book to do for us? Should it be a compilation of chapters giving the state - of - the - art in various theoretical and empirical areas? How about a set of tutorials (computer displays for events, math of the optic array, experimental techniques, etc.)? What else? There are a couple of ways you could help here: Suggest goals for the book and tell me the names of handbooks in other areas you feel would provide us with good models. Second, I'd like to get a variety of suggested chapter topics (and, if you like, names of people who'd be appropriate chapter authors). I suspect that the book won't wind up being entirely unitary. That is, I bet it will have a mix of tutorials, reviews of areas, annotated bibliographies, etc. So, even if you don't have answers to my first question, please send chapter topics. Include obvious ones which you are certain that other people will suggest. Redundancy helps. For example, if lots of people want a chapter reviewing the standard critiques of ecological psychology, this tells us that such a chapter ought to be included.

I realize that replies to such questions are not great pleasure to write. Still, the handbook has the potential to greatly influence the directions ecological psychology will take in the future. Thus, it will be important to do it right. Your help will be greatly appreciated.

Send ideas to: John Pittenger, Dept. of Psychology, UALR, 2801 S. University Ave., Little Rock, AR 72204 U.S.A. E-Mail to JBPittenger@Ualr. NOTE: Some systems want my name truncated to JBPitten.

Publications Database Project

The German speaking chapter of the ISEP is developing a database for papers dealing with the ecological approach. Please send your reference lists (publications concerned with ecoscience) to the following bitnet address: P110307@BORUB01.

I already have collected about 500 papers and book chapters (papers of E.J. & J.J. Gibson not included). "Grey" literature like tech reports and dissertations have not yet been included. But I think we should collect them. Until now we have included only papers advocating the ecological approach or working to advance it in experimental or theoretical ways. We want to extend the database to papers that criticize the ecological approach (e. g. Fodor & Pylyshyn, 1981). Contributors can send a short message with a reference to our bitnet address above. If you have published a paper (reference according the APA manual), It would be even better, if to send one reprint to my address, because we are trying to organize a "li-

brary" of ecoscience as well. For normal postal mail, send references and reprints to: Wolf Heine, Ruhr - Universität Bochum, Fakultät für Psychologie, Postfach 1021148, 4630 Bochum 1, FRG.

ESSAYS

Multiple Sources of Information: Threat or Menace?

John B Pittenger
U. of Arkansas—Little Rock

Early this year the notion of whether or not there exist multiple sources of information for perceived events was discussed in a flurry of Bitnet messages among some members of the society. While no one laid out a fully developed position, it seemed to me that the issue was either generating some disagreement or had revealed some ideas in need of clarification.

The following statement of my position is intended to motivate the theoretically inclined members of the Society to consider the issues and send in their own views. Two sorts of replies are especially desired. First, it would be good to see well - reasoned arguments for the claim that there are never multiple sources of information. If this is the case, we need to be sure of it. Second, I'd like to know what is wrong with the examples I've used. I expect that others, including opponents of the ecological perspective, use similar examples. Although we often do a good job on the first task, I think we tend to neglect the second. This I think is a mistake: The old examples just don't seem to go away. Notice for example the continuing use of the argument from illusion in critiques of J. J. Gibson's ideas!

Two claims

For years I have held two gut - level beliefs about multiple sources of information: 1) It is obvious that many everyday events are multiply specified and (2) Such multiple specification is fully consistent with a direct theory of perception. (By a "gut - level belief" I mean one which is firmly held even though the logical and empirical support for it hasn't actually been very well worked out.)

The first belief derives from a set of simple examples; fire, ball elasti- city and age. You can tell that a fire is occurring via smelling it, seeing it, hearing it and, with caution, feeling it. That is, there are at least four sources of information for this event (object?). If you wish to know how bouncy a ball is you can watch the rate at which the peaks of successive bounces become lower and lower and you can either watch or listen to the changes in frequency of contact with the ground. To perceive people's age you can attend to their head shape, the shape of parts of their face, or the height of their head relative to that of the rest of their body. The second belief follows from the fact that I've not seen any reasons to believe differently. More on this at the end of the essay.

The Bitnet discussions suggested to me that three topics need to be considered before we can fully understand multiple - specifications: what we shall mean by an object or event, what are appropriate criteria for deciding whether or not two apparently different sources of information are really the same, and what perceptual process are implied by the existence of multiple sources of information beyond those needed for unique sources. These topics are discussed in turn.

Multiplicity in the environment

One way around a claim that there are several sources of information for a given event (or object) is to show that there are really several different, though related, events (objects) being discussed, each with unique information in the array. That is, we've first got to get our heads straight about the environment before we can be sure about information for the environment. (Hum, that last sentence sure seems familiar.)

I suspect that some purported cases of multiple information can be made to go away on such grounds. Note for example Warren & Shaw's (1985) discussion of nested events. Recall that they cite an apple falling from a tree as a set of nested events. Just which event is perceived depends upon the perceiver's needs and activities; availability of food for a hungry animal, the ripening of the fruit for the apple picker, etc.

Another sort (well, I think its another sort) of multiplicity exists. For now let me call it *layering*. Consider a ball which is first at rest, then bounces and finally is grasped by the observer. That the object is a ball might first be perceived via detection of its size and shape. When we see it bounce we surely thereby know more than we did before. Note that if it were dropped but failed to bounce (say, became flattened and stuck to the floor) we would realize it wasn't a ball (but was a blob of hamburger.) Returning to the case in which it bounced, suppose I reach out and grab it. Again we know more than we did before. However, if my hand passed through the "ball", we'd know we had been earlier fooled—perhaps by a hologram.

I'm not quite sure what to make of "layering". As more sources of information become available are

we learning more and more about the same object or are we learning about different objects? That is, do there exist multiple, sources of information for one object or is this another case of different, but related, objects.

Finally, what about the fire example? Surely we can't use a multiple - events escape here; there is a fire there whether we feel, smell, hear, or see it. You could of course say that vision, hearing, etc. are different sources information for different properties of the fire. That sounds good — except than I don't understand what "fire" is. Surely we don't want to construct unity out of a bunch of properties. When are two sources really different?

As I thought about multiple - specification, it slowly dawned on me that I didn't know how to tell when it makes sense to say that two sources of information are different. After further thought, I still don't. I bet the issue is very important for ecological theory. We'd sure better be able to tell when two sources are the same. Even if its not vital to theory it still seems an interesting issue. I am not aware of any good treatment of the question in the literature. If there is published material, please advise. In the meantime, below are some examples and analyses.

It seems clear to me that different local aspects of a global source of information should not count as multiple sources. For example, change in the relative size of the forehead, of the length the nose and the protrusiveness of the jaw are all merely local aspect of cardioidal strain, the overall pattern of change in size and shape which occurs as the head grows. (The claim of sameness may not be justified; the local rate of growth is different at different locations on the head. Thus, this case may need further consideration.) Lee's tau in vision (Lee,1980) and sound provides another easy case; time - to - contact is specified both by the rate of expansion in the optic array and of the intensity of the sound at the perceiver's ear. Note here that the same relationship serves as information for the same fact about the observers relationship to the environment — all that is different is the modality over which it is carried.

Bouncing balls provide some mixed results. With a respect to perceiving elasticity, I can buy sameness in the temporal pattern of impacts with the ground via vision and hearing. Again its the same pattern (mushier balls damp faster) just via different pick-up systems. Also the seen heights of bounces will covary with the intensity of the sound when the ball hits the ground. Rates of change of these are equivalent. However, shall we say that the change in height and change in impact intervals are "the same"? Is strict covariance of two sources enough to call them "the same" or do we want the same mathematical function to occur in both? I'm not sure.

Other cases seem to be "really" different. That is, I can't see how to ground a claim of sameness. In the fire example how can we make crackling sounds and odor the same? Cutting's book (1986) provides other, and to me strong, examples.

Implications for theory

To this point I've talked myself into believing that we can dispense with some cases of proported multiple specification by showing that the multiplicity lies in the environment rather than in information. Other cases go away by showing that apparently different sorts of information aren't really different. However, I don't yet see how to make them all go away. This hasn't bothered me because I don't see why, as an ecological psychologist, I'd need to do so. That is, it seems to me that perception can be direct even if there are multiple sources of information.

Cutting's (1986) argument in favor of directed perception meets the issue head on and thus provides a good basis for my remarks. Much of his book is devoted toward empirical demonstrations of multiple sources of information. At the end of the book he argues that the existence of such sources requires us to abandon theories of direct perception and adopt what he calls directed theory.

The key to directed theory seems to lie in the fact that multiple sources of information will require multiple special-purpose mechanisms for their detection. "In direct perception, information specifies process (the individual picks up what is there, one source of information)—", (page 247). By contrast, with multiple sources of information there is an important implication for process. Since different sources will be detected by different special purpose devices, which device is used for perceiving a given object or event depends on what source is used in a given encounter with the object or event.

For present purposes, the question of importance is whether or not the processes required by multiple sources are any different from those required for dealing with unique sources. If not, direct perception is not challenged. Unfortunately Cutting is not very specific about the nature of the process. Undaunted, I'll suggest possible processing implications and comment on them.

As a preliminary, recall that under the ecological approach, arrays are full of information, much of which is irrelevant to an organism's current purposes. Ecologists rarely talk about the internal activ-

ities involved in search; exactly how search is guided, whether or not special purpose devices are "activated" so as to be ready to resonate, etc. Given these facts, let us now consider three cases of the system's use of multiple information.

Case 1: *Any source can be used.* This sounds to me like a parallel search; information is taken into the perceptual system, and when one of the sources is delected (by its own special purpose mechanism), perception occurs. I don't see how this is different from search for a single source. All that is required is that whatever occurs internally during a search for a single source occurs also in parallel when multiple sources are availabel. There is no threat to direct perception here.

Case 2: *Only one of the multiple - sources is to be used* This case is likely to be very important since it often seems to speak of different sources of information being used in different contexts. I expect that some examples of what appear to be this case actually involve nested events. That is, there is a different source of information for each sub - event (e.g. Warren and Shaw's apple example.)

Other instances however seem to involve multiple sources. For example, with an approaching object visual tau during the day and auditory at night. What new processes are required? Beats me. First consider the role of context when there are only unique sources. The perceptual system must have some way to control its internal processes so that, in a given context, it is attuned to the information relevant to the aspect of the environment of interest. That is, we all agree that direct theory can handle the situation; different information for different objects in different contexts. Now consider what would happen if we needed to use different information for some single event as a function of context. How could it matter whether or not the information - context pairs were tied to different events? As with unique sources the system searches for the information relevant to the context. When the information is detected the event, whatever event it happens to be, is then perceived.

Case 3: *Combining information.* This one may be the only dangerous case. It does seem to me that "combining" information (as in Bruno & Cutting's studies of combination of depth information). This sure sounds like it has to involve an internal process which a) detects information, in I'd suppose a direct way, and then b) does "something" with them. Whatever that something might be, it sure doesn't sound direct to me.

There may be an escape here. Perhaps some instances of this case involve what I earlier called "layering". If so, and if layering can be treated as different events, each with its own sort of information, we're ok. If not, we may have problems.

Conclusion

Well, the issues don't seem entirely resolved. Indeed, I now think they are more complex than I'd first supposed. While I may have greatly muddied the waters, there is at least one idea I see as of real potential use; there are three places at which we might draw the line on multiple information. First, is that there just aren't any instances of multiple sources. Second, there may be instances of multiple specification but their "processing" is direct. Third, multiple sources, being combined by the perceptual system, do pose a problem for direct theory.

References

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Warren, Jr., W.H. & Shaw, R.E. (1985). Events and encounters as units of analysis for ecological psychology. In W.H. Warren, Jr. & R.E. Shaw (Eds.), *Persistence and change: Proceedings of the first international conference on event perception* (pp. 1-27). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

A note on the utility of ecologically incomplete invariants [1]

Sverker Runeson
Dept. of Psychology, Uppsala University

In the course of the evolution of human vision, we might conjecture, all the existing variations within the retinal image have been utilized as stimuli for perception if they are consistently in correspondence with the actual lay of the land. (Gibson, 1950, p. 114)

...the information registered about objects and events becomes only what is needed, not all that could be obtained....only the information required to identify a thing economically tends to be picked up...(Gibson, 1966, p. 286)

Perceiving is flexible, opportunistic... (Gibson, 1967, p. 136)

A property of proximal structure (e.g. an optic array property) can constitute perceptually useful information if it varies monotonically with variation in a relevant distal property and at the same time remains invariant under the circumstantial variations (transformations) that do occur. Properties that exhibit this kind of invariance are therefore often referred to as "invariants" in perceptual theory. However, the desired invariance never occurs in an absolute sense — only if transformations are benign (non - destructive) to the informative property in question (Shaw & Pittenger, 1978). For this reason, the availability of informative invariants depends on the lawfulness and regularity of the events of the ecological system. More specifically, the informative value of a particular proximal property is contingent on the prevalence of a set of *constraints* such that the transformations that can actually occur are limited to those that are benign to the property. Thus, constraints are the necessary *grantors of information* (Runeson, 1988).

Complete invariants

Invariants can be granted by different sets of constraints. Some invariants require fewer constraints, others require more. There are constraints that are *ecologically universal*, that is, they hold throughout the relevant environment. Informative properties that rely only on such grantors can be called *ecologically complete invariants* (complete invariants, for short).

Several of the informative invariants that have been studied are examples of complete invariants in this sense: the constraints they rely upon are laws of nature and general characteristics of terrestrial environments (e.g. the flowfield properties analyzed by Lee, 1974). No doubt, there are many more complete invariants that are yet to be discovered by science. This is because we have a long way to go to chart all the constraints that are effective throughout ecological environments and to explore the informative invariants that they may be granting (Runeson, 1988).

Incomplete invariants

It is also possible to consider proximal properties that would be specific to something distal *if some further constraint(s) applied.* Such properties will be called *ecologically incomplete invariants*, that is, they are granted by constraints, some of which do not apply throughout the relevant environment. A looser way of defining an incomplete invariant would be to say that it is a property that differs in some way from a complete invariant but nevertheless has specificity for some subset of the cases that occur in the environment. That is, considered across the entire ecology it would provide some proportion of correct and false information, while within some more or less discernible local region (i.e. when some additional condition is fulfilled) it has full specificity.

The distinction between complete and incomplete invariants is not meant to be sharp or absolute. Rather, it will vary depending on how we delimit the relevant environment. For instance, we may want to analyze the general terrestrial environment. Alternatively, we may focus on the environment of a particular species or individual, or on a particular task situation. Generally, the purpose is to make use of the insight about the close dependence of invariants on constraints in order to capture the flexible nature of the informational value of many proximal properties. This way, a rigorous study of wider ranges of perceptually relevant information will become possible.

Why and how?

The ecological approach has the advantage of having shown that there *are* complete invariants of high perceptual relevance and which have been empirically shown to be effective in perceiving. However, there remains a need to explore properties that have more narrow ranges of invariance. The first thing to note is that there might be a good deal of biological "overkill" in many of the informative properties so far studied: their domain of invariance extends far beyond the ecological range. Other invariants, dependent on a few more constraints, hence of lesser invariance range, may still cover the ecological environment. They will then be complete invariants in the present sense and be equally potent as parts of the informational resources available to perceivers (Runeson, 1988).

The structured media that surround us also make available proximal properties that have the character of ecologically incomplete invariants. There are several reasons and ways that actual perceiving might occur on the basis of such proximal properties:

(a) The kind of perceptual system one has may not be suitable for the pickup of a particular complete invariant that is available.

(b) Due to the nature of perceptual systems and/or the individual's history of perceptual learning, certain incomplete invariants may be more easily or more quickly picked up than their complete counterparts and therefore be relied upon in actual perceiving.

(c) For the same reasons, properties that are not complete invariants may be discovered earlier in the process of acquisition of a perceptual skill. Thus incomplete invariants may be in use at intermediate stages of perceptual learning, later to give way to the use of more nearly complete invariants.

(d) The cases in which the use of an incomplete invariant leads to mistakes may be few or innocent enough to make it practically useful nevertheless.

Points (a) through (d) pertain to cases where perception occurs on the basis of incomplete invariants with less than perfect performance as the necessary result. The following three points describe ways that ecologically incomplete invariants can be rendered effectively complete.

(e) The individual has so far not gone outside the local region within which an incomplete invariant is fully invariant. Until he/she does, perceptual performance will be as well supported as it can and there will be little incentive nor opportunity to discover a complete invariant.

(f) The perceiver may use an incomplete invariant when inside the relevant local region and to switch to a different invariant (or remain perceptually uncommitted) when outside. This can occur whenever the limits of the regions (or the prevalence of the constraints) are themselves specified by some information.

(g) Alternatively, there is the possibility of a merging or concatenation of a few ecologically incomplete invariants by means of information specifying their regions of applicability into an effectively complete invariant.[2]

All in all, the notion of incomplete invariants can provide the ecological approach with a conceptual tool for handling cases of situation-specific perceptual proficiency as well as cases of generally low or intermediate levels of performance.[3] It can help explain why there need be no conflict between the facts of progressive improvement in perceptual learning and the all - or - none character of perception construed as pickup of information in the form of invariants. It also fits the differentiation theory of perceptual learning advanced by the Gibsons (Gibson & Gibson, 1955). In a way that is characteristic of the approach, the basis for a solution is found in the deeper nature of available information. In particular, the introduction of incomplete invariants suggests a possible mechanism for the acquisition of perceptual skills that preserves the notion of invariant-pickup for each stage of learning and each instance of perceiving. As suggested, improved performance could result either from the discovery of new, more nearly complete, invariants (point c) or from the use of concatenated invariants that consist of incomplete invariants together with information that specifies the conditions for their respective applicability (point f). It will also help emphasizing that exposure to less constrained conditions should provide both motivation and conditions for the discovery of better invariants (point e).

Cues?

Finally, it may seem that incomplete invariants would fit the conventional notion of "cues". Quite likely, some well - known cues could be interpreted as incomplete invariants. However, the current approach differs in important respects.

First, it is not suggested that all available informative properties are ecologically incomplete invariants — their introduction instead occurs in respect of the proven existence and effectiveness of complete invariants. Therefore no support is provided for the argument that constructive or probability - based inference processing has a necessary role in perception.

Second, it is not suggested that the incompleteness of incomplete invariants is due to inherent randomness in the relation between distal and proximal properties. Although applicable in principle, probability as a measure of degree of correspondence (e.g. Hammond, 1966, pp. 21, 28) may therefore fail to capture the relevant nature of incomplete invariants and thus may underestimate their psychological utility. Instead it is suggested that the validity of incomplete invariants is conditional or local in systematic fashion. Thus the more powerful notions of invariance under transformation and constraints as grantors of information may help bring in evidence a richer supply of information for perception — richer also than what can be demonstrated on the basis of complete invariants alone.

Third, it is not suggested that relevant incompletely invariant properties must be analytically simpler (e.g. lower - order variables) or more readily describable in terms of conventional physics concepts (e.g. of lower physical dimensionality). In line with the notion of smart mechanisms (Runeson, 1977), analytic or physics - theoretical complexity should provide no clues as to what properties may be perceptually more near at hand. The reasons incomplete invariants may sometimes be perceptually preferred or provide the default information before skill acquisition has taken place are instead to be found in the characteristics of perceptual systems and in previous perceptual learning.

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Notes

[1] Based on part of a paper presented at the Fifth International Conference on Event Perception and Action, Miami University, Oxford OH, July 1989. Research supported by The Bank of Sweden Tercentenary Foundation (RJ) and The Swedish Council for Research in the Humanities and Social Sciences (HSFR).

[2] The notion of "gauge invariants" in physics might be relevant for this case. (Thanks to William Mace and Robert Shaw for the notice.)

[3] This will be in addition to the possible role of imperfect precision or gradual emergence of specific sensitivity in the pickup process (cf. the selectionist type of explanations).

MISPERCEPTIONS OF THE MONTH

Dear Dr. Mace,

I am passing along a quote that you may want to consider for the next (theoretical) misperception of the month:

"One might ask why infants can't simply 'look around' to see what's really going on. Unfortunately, the easy-sounding phrase 'simply look' conceals too many hard problems. When you look at an object, some light from it shines into your eye and stimulates some sensors there. However, every motion of your body, head, or eye makes drastic changes to the image in your eye. How can we extract any useful information when everything changes so rapidly? Although it should be possible, in principle, to design a machine that could eventually learn to relate those motions to the resulting changes in the images, this would surely take a long time, and it appears that our brains have evolved with special mechanisms that help us compensate for motions of the body, head, and eye" (Minsky, 1986, p. 114).

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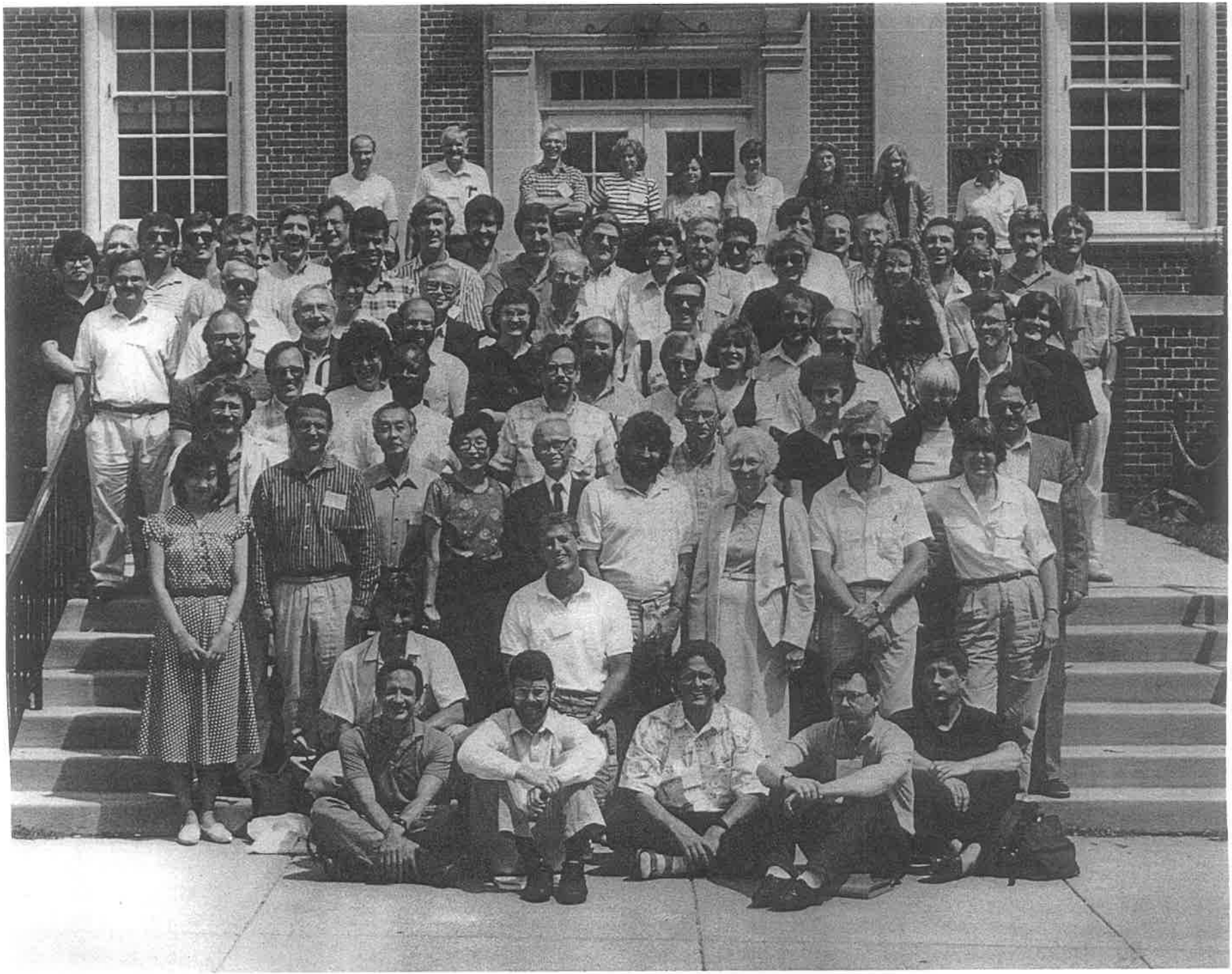
Kim Vicente



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TRINITY COLLEGE
HARTFORD, CONNECTICUT 06106